Quantum repeaters using ensembles of coupled quantum dots

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We propose quantum repeaters based on semiconductor technologies which have good interfaces with optical fiber communication and can achieve high fidelity of entanglement.

In asymmetric coupled two quantum dots, four exciton levels are formed as the result of the combination of two electron levels and two hole levels. Three of them are relevant to Raman transitions. The lowest level could contribute destructively to the process due to the resonance. However, if we take into consideration the energy shift by each intra-dot coulomb interaction, such process can be neglected. The advantage of our scheme is its good interface with the fiber-optical communication. Moreover, the electric field applied via gate electrodes can modulate the wavelength of Stokes photons. After the successful Bell measurement, the state of the two lambda systems is projected into entangled state. However, the relative phase is very sensitive to the fluctuation of optical lengths of both modes. We have a method to control the phase by applying gate voltage. Actual procedure would be such that among the Bell measurement periods the time periods of calibration of interferometer are inserted, where the correlation function of σ_x is monitored and the output is fed back to the gate voltage negatively.

Practical photodetector has nonzero dark count rate and nonideal quantum efficiency. The post-selection is influenced by this imperfection of photodetectors. The fidelity of entanglement under this effect is analyzed. It is shown that we need to choose appropriate Raman amplitude in order to maximize the fidelity of entanglement, depending on the characteristics of the detectors used. Practical high fidelity would be possible using recently developed high performance photon detectors.

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